Co-design of the Medical Assistive and Transactional Technologies system

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Abstract — This paper could argue that the co-design method is strongly needed to design acceptable and usable assistive technologies. It describes the co-design of the Medical Assistive and Transactional Technologies (MATT) system. This method was implemented for Matthieu a quadriplegic and a non verbal person. The paper reports how the collaborative design was running between Matthieu, his occupational therapists, his family and the designer team.

Index terms: Disability, E-health, Modeling

I. INTRODUCTION

"*In memory of Matthieu*"

Information technology and communication take an important place and their use can represent a significant social issue for the disabled population. Not considering the contribution of these technologies and not taking into account the special needs of people with disabilities (whether temporally or permanent) exclude them by preventing them or limiting the access to education, the world of work or culture. The development of Assistive Technology (AT) can be an answer if it meets their needs. Even when barriers to obtaining AT devices are overcome, users often abandon their devices. Many studies show that high abandonment rate of AT may be important; it is usually because potential users have no representation of AT; some difficulties in obtaining devices carefully adapted to meet the needs of very demanding users; sometimes low performance of AT or their inability to adapt to new users' functional abilities that are inevitably imposed by the development of impairment. Riemer-Ress and Wacker [1] reported additional explanations such as environmental barriers dependent of the disability and also fear of technology. Philips and Zhao [2] related that almost one third of all the user's AT were completely abandoned. This high rate of abandonment ascertained that a large percent of AT devices are not meeting users' needs. Consequently, there is a strong demand for practical, customized and reliable AT. The difficulty to collect and to understand the needs of disabled person is often described in the literature. Hurst and Tobias [3] illustrates that it is possible to custom-build AT and argues why empowering users to make their own AT can improve the adoption process. Boujrad et al. [4] have developed a participatory approach with patients and therapists to design a human computer interface for quadriplegic. The ISO 9 241-210 standard [5] recommends an active involvement of persons who will use the AT in the four phases of the design process: Need analysis; brainstorming (idea); design and quick prototyping and evaluation against the requirements. There are also new ways where the end-user is participating as an actor to co-design and to evaluate his/her own AT. This co-design principle is a tool which takes place in the development of Living Labs (www.forumllsa.org) in health and autonomy. This paper will describe how the needs and the user's satisfaction criteria of Matthieu have been considered in the co-design of the MATT's scanning system. It will also report the crucial role of the family caregivers and formal careers in the co-design and trials.

II. CASE STUDY OF MATTHIEU

Matthieu was living in a rehabilitation center near Paris. He was a quadriplegic person without spoken communication. Matthieu also had visual deficiency. He communicated with his family and his caregivers through his thumb movement. Matthieu only answered by two consecutive movements which mean "yes" (*Figure 1*). In this context, the dialog between Matthieu and his human environment –family and caregivers– was long, poor and difficult even if some facial expressions report Matthieu's intention. The learning to understand Matthieu was long time consuming. Consequently, the therapist team is heavily work loaded. In consequence Matthieu wished to be more independent and more autonomic to choose his leisure time – free to select himself the music played, the movie watched on the Web, the TV channel or the radio. He liked also to express his needs or feels as "I am cold", "I am not installed in my chair", "I want to change room", etc. to anyone. To meet the needs of Matthieu, a user centered approach was lead including the therapist team, his father, his brother and a team specialized in the design of AT. After some observations the design team has decided to design a virtual keyboard with scanning controlled by a switch connected to the input/output of an Arduino Uno box (http://www.arduino.cc).

III. MATT'S SCANNING SYSTEM

The SOftware KEYboard Toolkit [6] has been used to design MATT's scanning system. This platform enables to design virtual keyboards for communication, environment control, and computer application like Internet or audio message linked to a key. This platform permits to choose the type of interaction –pointing or scanning –and its settings. It also offers highly reconfigurable options to adapt the MATT system to the abilities of the user.

Figure 1: Matthieu's thumb movement

Figure 2: Matthieu's switch position

IV. USER CENTERED DESIGN METHOD

The characteristics (pictographic representation, interaction techniques, and sound feedback) have been iteratively defined with close collaboration with the therapists and the family (*Figure 3*).

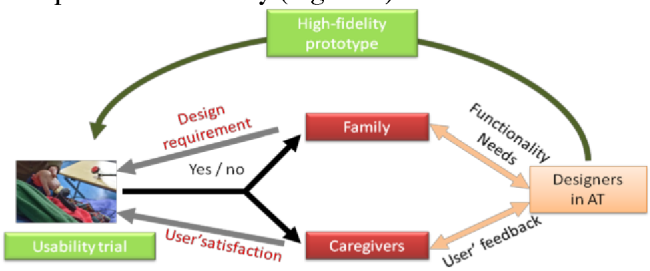

Figure 3: Iterative co-design

We conducted a participatory design process [7] during six months with Matthieu. This design was also based on the ergonomic criteria [5]. Matthieu was personally involved through his trials. Several adaptations of the scanning system were done:

- Visual, spatial and hierarchical presentation of pictograms ;
- Options of pictograms reading to acquire a mental representation of the MATT layout ;
- Double pressure on the switch (*Figure 2*) (400 ms) to keep the current principle of human communication;
- Personalized scanning system to avoid cognitive overload;
- Invisible scanning system during the playing of a movie to avoid overlapping.

Hence, we have proposed an approach based on high-fidelity iterative prototypes allowing both to test the design of the MATT's AT and to identify the interaction capabilities and needs. To maximize experience feedbacks with a minimal cost implementation, we initially used technologies "off the shelf" in particular for the hardware part. This step was very important in the definition and the criticality of the offered services recommended. Redesigns have been made to meet the needs and the abilities of Matthieu. Matthieu and his family have strongly appreciated the possibility of quickly adapting the MATT system. This co-design phase has demonstrated the needs to have a good visual representation of pictograms. The vocal restitution of the pictogram made easier the training of the MATT interactive system.

V. DISCUSSION – CONCLUSION

The iterative design cycle has to be adapted for our study. We had to make a high number of cycles between a state of the prototype and a test phase. The trials have often been partial: they often concern one dimension of the interaction: feedback, scanning, pictogram arrangement and representation, double click definition … because only one scanning system setting is unsuitable for the end-user. These fine settings have needed a close collaboration between the designers and the therapist team to schedule the design and test priorities. These difficulties must be considered within the deployment of a user centered method and the Do-It-Yourself Assistive Technology [3].

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